Wilson Bull., 100(2), 1988, pp. 272–284

CONSERVATION OF RIPARIAN ECOSYSTEMS IN THE UNITED STATES[1]

FRITZ L. KNOPF,[2,3] R. ROY JOHNSON,[4] TERRELL RICH,[5]
FRED B. SAMSON,[6] AND ROBERT C. SZARO[7]

Riparian ecosystems include relatively mesic vegetative communities and associated faunas occurring between aquatic and more xeric upland sites. In eastern North America, these ecosystems often occur in broad zones and are referred to as floodplains or bottomlands. In the west, they are conspicuous as narrow belts of vegetation along ephemeral, intermittent, and perennial streams and rivers and are most obvious in steppe, shrubsteppe, and desert regions. Vegetation associated with streams has been referred to as the "aorta of an ecosystem" (Wilson 1979:82) because of its significance to the perpetuation of water, fish, wildlife, rangeland, and forest resources.

Historically, riparian ecosystems have been subjected to both subtle and dramatic perturbations from water management practices (Carothers and Johnson 1975, Curtis and Ripley 1975) (Fig. 1), agricultural conversions (Best et al. 1979, Conine et al. 1979), grazing (Cope 1979, Knopf and Cannon 1982), channelization (Barclay 1979, McCall and Knox 1979), and recreational development (Aitchison 1977, Schmidly and Ditton 1979, Johnson and Carothers 1982). Riparian systems represent areas of maximum potential conflict between users of timber, grazing, recreational, water, and wildlife resources (Thomas et al. 1979). Additionally, exotic woody species such as salt cedar (*Tamarix pentandra*) and Russian olive (*Elaeagnus angustifolia*) have naturalized extensively within western riparian ecosystems (Robinson 1965, Horton 1977, Olson and Knopf 1986b), displacing native woody species that provide valuable avian habitats but also providing additional habitats for selected species of wildlife (Knopf and Olson 1984, Hunter et al. 1985).

Riparian ecosystems have recently attracted much attention, especially relative to the management of public lands in the west. Within the last

[1] Report of the Conservation Committee; *Received 31 May 1987, accepted 20 Oct. 1987.*
[2] Committee Chairman
[3] National Ecology Center, U.S. Fish and Wildlife Service, 1300 Blue Spruce Drive, Fort Collins, Colorado 80524-2098.
[4] U.S. National Park Service, #125 Biological Sciences East, Univ. Arizona, Tucson, Arizona 85710.
[5] U.S. Bureau of Land Management, Box 1229, Dickinson, North Dakota 58602.
[6] U.S. Forest Service, Forestry Sciences Laboratory, 3625 93rd Avenue S.W., Olympia, Washington 98502.
[7] U.S. Forest Service, Forestry Sciences Laboratory, Arizona State Univ. Campus, Tempe, Arizona 85287.

FIG. 1. Stressed stand of plains cottonwoods (*Populus sargentii*) along the (now dry) channel of the Cheyenne River near Wasta, South Dakota. (Photo. 21 Sept. 1982 by F. L. Knopf.)

10 years, conservation of riparian systems has been the topic of one international (Johnson et al. 1985), two national (Johnson and McCormick 1979, Sharitz and Gibbons 1988), and many regional (e.g., Johnson and Jones 1977, Graul and Bissell 1978, Cope 1979, Warner and Hendrix 1984) technical conferences.

THE RIPARIAN AVIFAUNA

Less than 1% of the western landscape of the United States is covered by riparian vegetation. However, this vegetation provides habitats for more species of breeding birds than surrounding uplands. Eighty-two percent of all species annually breeding in northern Colorado occur in riparian vegetation (Knopf 1985), and 51% of all species in southwestern states are completely dependent upon this vegetation type (Johnson et al. 1977). Loss of the riparian component in the southwestern states could potentially result in the loss of 78 (47%) of the 166 avian species that breed in the region (Johnson et al. 1977). In New Mexico, losses of 46%

of the species breeding in the San Juan Valley (Schmitt 1976) and 49% of the species breeding in the Gila Valley (Hubbard 1971) might be expected. Hubbard (1977:16) speculated that "these two New Mexico river valleys support 16–17% of the entire breeding avifauna of temperate North America." Similar relationships, although less dramatic, have been observed in the eastern United States (Dickson 1978, Best et al. 1979, Hair et al. 1979, Stauffer and Best 1980).

Riparian vegetation attracts a greater number and variety of bird species during migration than during the breeding season. Riparian systems may attract up to 10.6× the number of migratory birds found in surrounding upland sites in the spring (Stevens et al. 1977) and 14× the number of species recorded during fall migration (Hehnke and Stone 1979). These differences occur almost exclusively in the insectivorous bird foraging guild, with granivorous species being associated more with upland (Stevens et al. 1977) or altered (Heller 1978) sites. However, granivorous species do use riparian sites extensively during winter for foraging and thermal cover (F. B. Samson and F. L. Knopf, unpubl. data).

The disproportionately high value of riparian vegetation in providing habitats extends beyond birds to other vertebrates (Brode and Bury 1984, Cross 1985, Bury, 1988).

U.S. PUBLIC LANDS POLICIES

Riparian ecosystems managed by natural resource agencies historically have been subjected to policy directives favoring adjoining vegetative associations. Only recently have riparian systems received special emphasis based upon their unique attributes.

Federal land-management agencies of the United States presently operate under executive and legislative mandates for riparian conservation. Specific federal authorities for conserving riparian vegetation do not exist; however, guidelines for management of riparian ecosystems on public lands are provided in two Executive Orders. Executive Order No. 11988, entitled "Floodplain Management," recognizes the importance and unique nature of the nation's floodplains and requires agencies (to the extent possible) to avoid adverse impacts associated with occupancy and modification of floodplains. Further, agencies are to avoid direct or indirect support of floodplain development whenever a practical alternative can be identified. A second Executive Order (No. 11990, "Protection of Wetlands") directs agencies to take necessary actions to minimize the loss or degradation of wetlands and to provide leadership in preserving and enhancing the natural and beneficial values of these areas.

In addition to these executive orders, general guidelines for conserving riparian and other natural areas are provided in legislative bills including

The National Environmental Policy Act, Federal Land Policy and Management Act, Land and Water Conservation Fund Act, Fish and Wildlife Coordination Act, National Forest Management Act, Federal Water Pollution Control Act, and Public Rangelands Improvement Act. The extent to which individual public lands agencies have developed internal guidelines based on these executive and legislative authorities varies with the charge for wildlife conservation legislated to that agency.

U.S. Department of Agriculture, Forest Service.—The Forest Service (FS) manages 35,903,804 ha of land, of which 33,261,675 ha are in the contiguous states (U.S. Dept. Agric. 1982). Specific directions regulating floodplain and riparian management on FS lands are found in the National Forest Management Act (NFMA) of 1976 and NFMA implementation regulation 36 CFR Part 219. The regulations state that land dominated by riparian vegetation within 30 m of perennial streams, lakes, and other water bodies will be given special attention. Management practices that adversely affect water condition and fish habitat in these areas are to be avoided. Other factors (e.g., topography, vegetation type) should be considered in determining what management practices are acceptable in these areas.

The Forest Service Manual (U.S. Dept. Agric. 1980) recognizes the unique values of riparian areas and emphasizes their protection, management, and improvement during the planning and implementation of land and resource management activities. The policy is to manage riparian areas relative to legal mandates, including those associated with, but not limited to, floodplains, endangered species, wetland resources, and water quality. Specifically, the policy is to: (1) recognize the importance and values of riparian areas during the land management planning process; (2) recognize the importance and distinctive value of riparian areas when implementing management activities and give preferential consideration to riparian area resources vs other resources in cases of unresolvable conflict; (3) manage riparian areas under the principles of multiple use and sustained yield, while emphasizing protection of soil, water, vegetation, and fish and wildlife resources; and (4) identify riparian areas prior to implementation of any project activity.

The FS responsibilities for riparian area management differ with administrative level (U.S. Dept. Agric. 1980). The FS Chief is responsible for National Policy, the minimum-protection standard, coordination of research programs, and coordination with other federal agencies at the national level. The Regional Forester is responsible for: (1) ensuring that riparian areas are addressed in the land management planning process; (2) providing technical standards, guidelines, training, and quality control for the management of riparian areas (Forest Service Manual 1921.43);

(3) monitoring the effectiveness of measures implemented for the protection and improvement of riparian areas; and (4) defining more specific criteria to identify and delineate soils, land forms, and vegetation in riparian areas. The Forest Supervisor is responsible through the land management process for the inventory, management, and protection of riparian areas according to national and regional objectives and standards. District personnel in each forest do the groundwork which includes identifying riparian areas most likely to be influenced by a proposed activity, classifying resource values within riparian areas, and (with the assistance of specialists) assigning resource protection values.

An additional requirement of the Forest Service is to monitor and evaluate management activities applied within riparian areas and to coordinate with federal, state, and local agencies to ensure that all activities are conducted in an environmentally, socially, and economically acceptable manner. In general, a more intensive monitoring system is suggested for riparian areas in that they are more susceptible to multiple impacts than are terrestrial systems.

U.S. Department of Agriculture, Soil Conservation Service.—The Soil Conservation Service (SCS) does not manage public lands, per se, but serves as an advisory organization for private individuals. Recognition of the special value of wetlands as wildlife habitats has evolved over the course of the last 50 years in the SCS. Although wetlands programs have emphasized marshlands on the Great Plains, numerous projects have affected the conservation of riparian vegetation locally (Barry 1979). Nonetheless, specific written policies on riparian conservation have not been developed (D. E. Chalk, pers. comm.).

U.S. Department of Defense, Army Corps of Engineers.—Beyond federal mandates and legislation, the Corps of Engineers has no stated riparian policy or guidelines within the agency. The general philosophy of the Corps recognizes that riparian systems are important and should be considered in agency projects and mitigation efforts (J. O'Neal, pers. comm.); Corps projects are subjected to Fish and Wildlife Service (FWS) review.

U.S. Department of Interior, Bureau of Land Management.—The Bureau of Land Management (BLM) administers 190,206,390 ha of public lands, or about 20% of the surface area of the United States (Almand and Krohn 1979). Approximately 69,798,057 ha of this area are in the western contiguous states, and the remainder is in Alaska. As with the FS, wildlife conservation is one of many charges of the agency, and riparian issues have received more specific guidelines in policy and levels of management responsibility than other vegetative communities.

Four basic policies safeguard riparian ecosystems on BLM lands (Almand and Krohn 1979). These include: (1) avoiding adverse impacts on

riparian areas when possible; (2) avoiding new construction in riparian areas where a practical alternative is available; (3) preserving and enhancing riparian sites and regulating those uses causing irreparable damage; and (4) minimizing actions causing definable adverse impacts.

BLM published formal guidelines for management of riparian areas in the *Federal Register* in 1980 (44 CFR 36121). Those guidelines have been incorporated into the BLM Manual for operations. Briefly, the Director and Associate Director are responsible for integration of riparian conservation into Bureau policies: this responsibility generally is exercised through the Deputy Director for Lands and Resources. The Chief, Office of Budget ensures that appropriations requests conform to Executive Order 11990. State Directors and Division Chiefs ensure compliance with defined procedures for riparian protection and management, with actual inventories and monitoring of riparian condition being the responsibility of District Managers. District and Resource Area Specialists identify and evaluate riparian sites. Recommendations for project work, management changes, and monitoring are then developed. In Fiscal Year 1986, each state office of BLM developed a riparian area management strategy outlining the future inventory and management of all riparian areas. Implementation of this strategy will be a high priority within all BLM programs in the future.

U.S. Department of Interior, Bureau of Reclamation.—Much of the 3,026,325 ha (U.S.D.I. 1984) of land held by the Bureau of Reclamation (BOR) is managed by other agencies. Reservoir lands may be managed by state park and wildlife agencies or federal authorities (e.g., National Park Service). "Reclamation withdrawn" lands (those with water delivery or irrigation potential) are also frequently managed by other agencies, principally the BLM. Despite primary management at a site by other agencies, the nature of BOR's activities relative to water resources results in a large measure of control over western riparian systems (Busch 1984). BOR projects designed to develop water resources are conducted in compliance with federal mandates, and the agency is a cooperator in riparian habitat and species management programs. However, BOR guidelines do not specifically address riparian or wildlife issues (D. E. Busch, pers. comm.).

U.S. Department of Interior, Fish and Wildlife Service.—The Fish and Wildlife Service (FWS) manages 36,584,591 ha of which 32,782,580 ha are within the National Wildlife Refuge System. The remaining 3,802,011 ha are managed for secondary interests (i.e., wildlife) on lands owned by other public agencies or through legal agreements, easements, and leases (FWS Realty Office Statistics, 7 July 1986). The FWS does not have specific policies relative to management of riparian vegetation for wildlife

habitats at the national level. Rather, riparian conservation and enhancement are accomplished within FWS programs to promote wildlife conservation by: (1) land acquisition, (2) environmental planning and regulatory processes, and (3) resource inventories and basic research (Hirsch and Segelquist 1979).

Most riparian efforts have arisen directly from the FWS's responsibilities for protection and management of migratory birds—particularly waterfowl. Refuges such as Santa Ana, White River, Columbia White-tailed Deer, Havasu, and Upper Mississippi River are comprised primarily of riparian vegetation and have been purchased, in part, to protect the unique diversity of wildlife on those sites. The FWS tasks associated with reviews of environmental impacts and recommendations for mitigation of resource losses on federally funded water resource projects often emphasize wetlands, including riparian, issues. This authority is granted through the Fish and Wildlife Coordination Act, and the FWS has primary responsibility for reviewing projects by the COE and BOR, specifically.

Riparian systems usually are classified within Resource Category 1 (all losses should be prevented) or 2 (agency should strive for no net loss). As Hirsch and Segelquist (1979) observed, however, such review is advisory in nature and lacks enforcement power.

U.S. Department of Interior, National Park Service.—National Park Service (NPS) lands are protected for natural, cultural, recreational, developed, or special uses. The NPS manages the natural resources of the Nation's parks to maintain and perpetuate their inherent integrity. Because the agency is dedicated to the concept of perpetuation of a total natural environment or ecosystem rather than of providing resources for specific users, the NPS generally has not developed policies regarding specific natural resources such as riparian areas.

ON THE LOCALIZED FOCUS OF RIPARIAN CONSERVATION

Factors contributing to the local diversity of avian species in riparian vegetation have been identified in numerous studies (Stauffer and Best 1980, Szaro 1980, and others) as have impacts of specific disturbances on avian habitats (Barclay 1979, Sedgwick and Knopf 1987, and others). These studies of riparian avifaunas and management activities generally have been local in nature, because broad conservation guidelines are difficult to develop for such variable systems (Szaro 1980). Thus, agency policies and guidelines generally direct conservation and enhancement actions at a specific site (project or management unit) based upon local evaluations.

We see two potential dangers in developing management policy upon a site-specific information base, especially when viewed from a national

perspective. First, local information can foster erroneous conclusions regarding the biological contribution of a specific association to the continental avifauna. This point was illustrated with the evaluation of conservation priorities examining beta and gamma levels of diversity (cf. Whittaker 1975) within forest bird communities at Jackson Hole, Wyoming (Samson and Knopf 1982). Whereas riparian vegetation provides habitats for many species of birds in northwestern Wyoming, most of those species either are cosmopolitan or on the periphery of their continental distribution. In contrast, the local forest type (lodgepole pine [*Pinus contorta*]) that has the poorest species richness provides habitats for a number of species that are regionally unique when viewed from a national perspective. Management emphasis upon habitats for riparian species at Jackson Hole would be at the expense of efforts to conserve the unique elements of the regional avifauna. National guidelines and policies, to date, assure that primary emphasis is on riparian vegetation within all projects—and potentially towards a continentally cosmopolitan avifauna at many sites.

A second potential danger stems from the tendency to view site-specific data as finite, bounded information. Riparian tracts along major river systems constitute corridors of habitat for birds. Bird communities are more similar among riparian than among upland vegetation types at sites across a watershed (Knopf 1985), and some species may migrate along riparian corridors seasonally (Wauer 1977). The tendency for birds to move within riparian corridors is fundamental to the cosmopolitism issue, and a corridor of riparian vegetation can foster extensive faunal mixing where it crosses a historic, geographic barrier to avian dispersal (Knopf 1986). Current thinking relative to the conservation of landscapes has been preoccupied with the application of area components of island biogeography theory to patterns of population dispersion (Willson and Carothers 1979, Harris 1984, Risser et al. 1984, Norse et al. 1986) rather than on an approach that emphasizes animal redistribution as a function of dispersal capabilities and probabilities (e.g., Simpson 1965). Vertebrate conservation within riparian ecosystems, especially, needs to be based upon the perspective of whether local management programs create or sever dispersal corridors.

SUMMARY AND RECOMMENDATIONS

Riparian vegetation occurs on <1% of the western North American landscape, yet it provides habitats for more species of birds than all other vegetation types combined. Riparian ecosystems tend to be subjected to extensive disturbance. Besides diversion of water from streams and the subsequent stress placed upon the vegetative community, these ecosys-

tems are subjected to agricultural conversions, grazing, channelization, recreational development, and colonization by exotic plants. Given the high value of riparian ecosystems relative to surrounding uplands as wildlife habitats throughout the West, we offer the following recommendations:

(1) The U.S. Congress assign enforcement powers to FWS for charges delegated within the Fish and Wildlife Coordination Act. FWS powers should extend across all federal agencies.

(2) Public agencies (state and federal) review user fees for riparian areas to assure that rates reflect the enhanced wildlife value that these systems provide.

(3) Each public land management agency develop specific, internal, procedural guidelines for addressing riparian issues to reflect regional-level planning rather than conservation or enhancement actions justified upon local criteria. In addition, each agency should voluntarily make their riparian policies public and assure the visibility of those policies.

(4) Respective agencies coordinate planned management actions within an identified drainage (Clark 1980, Mantell et al. 1985, Knopf 1986), preferably with responsibility for coordination being assigned to a designated individual with agency-wide authority.

(5) Agencies should develop new technologies to discourage the spread of exotics within native riparian ecosystems, with both state and federal agencies discontinuing subsidization of exotic woody species (Olson and Knopf 1986a) that have demonstrated the ability to naturalize within riparian communities and displace native species.

ACKNOWLEDGMENTS

Numerous individuals assisted in accessing information on agency positions and policies. We especially thank those who have been acknowledged for personal communications in the text of the report. J. A. Sedgwick assisted in technical aspects of manuscript preparation.

LITERATURE CITED

AITCHISON, S. W. 1977. Some effects of a campground on breeding birds in Arizona. Pp. 175–182 *in* Importance, preservation and management of riparian habitat: a symposium (R. R. Johnson and D. A. Jones, Jr., tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-43.

ALMAND, J. D. AND W. B. KROHN. 1979. The position of the Bureau of Land Management on the protection and management of riparian ecosystems. Pp. 359–361 *in* Strategies for protection and management of floodplain wetlands and other riparian ecosystems (R. R. Johnson and J. F. McCormick, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-12.

BARCLAY, J. S. 1979. The effects of channelization on riparian vegetation and wildlife in south central Oklahoma. Pp. 129–138 *in* Strategies for protection and management of

floodplain wetlands and other riparian ecosystems (R. R. Johnson and J. F. McCormick, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-12.

BARRY, V. H., JR. 1979. Soil Conservation Service and riparian ecosystems: a long-term view. Pp. 353–358 *in* Strategies for protection and management of floodplain wetlands and other riparian ecosystems (R. R. Johnson and J. F. McCormick, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-12.

BEST, L. B., D. F. STAUFFER, AND A. R. GEIER. 1979. Evaluating the effects of habitat alteration on birds and small mammals occupying riparian communities. Pp. 117–124 *in* Strategies for protection and management of floodplain wetlands and other riparian ecosystems (R. R. Johnson and J. F. McCormick, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-12.

BRODE, J. M. AND R. B. BURY. 1984. The importance of riparian systems to amphibians and reptiles. Pp. 30–36 *in* California riparian systems (R. E. Warner and K. M. Hendrix, eds.). Univ. Calif. Press. Berkeley, California.

BURY, R. B. Habitat relationships and ecological importance of amphibians and reptiles. *in* Streamside management: riparian wildlife and forestry interactions (K. J. Raedeke, ed.). Inst. For. Resour., Univ. Wash., Seattle, Washington. In press.

BUSCH, D. E. 1984. Environmental data system of the Bureau of Reclamation. Pp. 335–339 *in* California riparian systems (R. E. Warner and K. M. Hendrix, eds.). Univ. Calif. Press. Berkeley, California.

CAROTHERS, S. W. AND R. R. JOHNSON. 1975. Water management practices and their effects on nongame birds in range habitats. Pp. 210–222 *in* Symposium on management of forest and range habitats for nongame birds (D. R. Smith, ed.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-1.

CLARK, J. R. 1980. River corridor approach to bottomland management. Trans. North Am. Wildl. and Nat. Resour. Conf. 45:387–391.

CONINE, K. H., B. W. ANDERSON, R. D. OHMART, AND J. F. DRAKE. 1979. Responses of riparian species to agricultural habitat conversions. Pp. 248–262 *in* Strategies for protection and management of floodplain wetlands and other riparian ecosystems (R. R. Johnson and J. F. McCormick, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-12.

COPE, O. B. 1979. Grazing and riparian/stream ecosystems. Trout Unlimited, Inc. Denver, Colorado.

CROSS, S. P. 1985. Responses of small mammals to forest riparian perturbations. Pp. 269–275 *in* Riparian ecosystems and their management: reconciling conflicting uses (R. R. Johnson, C. D. Ziebell, D. R. Patten, P. F. Ffolliot, and R. H. Hamre, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-120.

CURTIS, R. L. AND T. H. RIPLEY. 1975. Water management practices and their effect on nongame bird habitat values in a deciduous forest community. Pp. 128–141 *in* Symposium on management of forest and range habitats for nongame birds (D. R. Smith, ed.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-1.

DICKSON, J. G. 1978. Forest bird communities of the bottomland hardwoods. Pp. 66–73 *in* Management of southern forests for nongame birds (R. M. DeGraaf, ed.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. SE-14.

GRAUL, W. D. AND S. J. BISSELL, EDS. 1978. Lowland river and stream habitat in Colorado: a symposium. Colorado Chap., The Wildl. Soc. and Colo. Audubon Counc. Denver, Colorado.

HAIR, J. D., G. T. HEPP, L. M. LUCKETT, K. P. REESE, AND D. K. WOODWARD. 1979. Beaver pond ecosystems and their relationships to multi-use natural resource manage-

ment. Pp. 80–92 *in* Strategies for protection and management of floodplain wetlands and other riparian ecosystems (R. R. Johnson and J. F. McCormick, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-12.

HARRIS, L. D. 1984. The fragmented forest. Univ. Chicago Press. Chicago, Illinois.

HEHNKE, M. AND C. P. STONE. 1979. Value of riparian vegetation to avian populations along the Sacramento River system. Pp. 228–235 *in* Strategies for protection and management of floodplain wetlands and other riparian ecosystems (R. R. Johnson and J. F. McCormick, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-12.

HELLER, V. J. 1978. The effects of stream alteration and associated land use changes on a riparian avifauna in southcentral Oklahoma. M.S. thesis, Oklahoma State Univ. Stillwater, Oklahoma.

HIRSCH, A. AND C. A. SEGELQUIST. 1979. Protection and management of riparian ecosystems: activities and views of the U.S. Fish and Wildlife Service. Pp. 344–352 *in* Strategies for protection and management of floodplain wetlands and other riparian ecosystems (R. R. Johnson and J. F. McCormick, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-12.

HORTON, J. S. 1977. The development and perpetuation of the permanent tamarix type in the phreatophyte zone of the Southwest. Pp. 124–127 *in* Importance, preservation and management of riparian habitat: a symposium (R. R. Johnson and D. A. Jones, Jr., tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-43.

HUBBARD, J. P. 1971. The summer birds of the Gila Valley, New Mexico. Nemouria No. 2.

———. 1977. Importance of riparian ecosystems: biotic considerations. Pp. 14–18 *in* Importance, preservation and management of riparian habitat: a symposium (R. R. Johnson and D. A. Jones, Jr., tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-43.

HUNTER, W. C., B. W. ANDERSON, AND R. D. OHMART. 1985. Summer avian community composition of tamarix habitats in three southwestern desert riparian systems. Pp. 128–134 *in* Riparian ecosystems and their management: reconciling conflicting uses (R. R. Johnson, C. D. Ziebell, D. R. Patten, P. F. Ffolliot, and R. H. Hamre, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-120.

JOHNSON, R. R. AND S. W. CAROTHERS. 1982. Riparian habitats and recreation: interrelationships and impacts in the Southwest and Rocky Mountain region. U.S. Dep. Agric., For. Serv. Eisenhower Consortium Bull. 12.

——— AND D. A. JONES, TECH. COORDS. 1977. Importance, preservation and management of riparian habitat: a symposium. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-43.

——— AND J. FRANK MCCORMICK, TECH. COORDS. 1979. Strategies for protection and management of floodplain wetlands and other riparian ecosystems. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-12.

———, L. T. HAIGHT, AND J. M. SIMPSON. 1977. Endangered species vs. endangered habitats: a concept. Pp. 68–79 *in* Importance, preservation and management of riparian habitat: a symposium (R. R. Johnson and D. A. Jones, Jr., tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-43.

———, C. D. ZIEBELL, D. R. PATTEN, P. F. FFOLLIOT, AND R. H. HAMRE, TECH. COORDS. 1985. Riparian ecosystems and their management: reconciling conflicting uses. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-120.

KNOPF, F. L. 1985. Significance of riparian vegetation to breeding birds across an altitudinal cline. Pp. 105–111 *in* Riparian ecosystems and their management: reconciling conflicting uses (R. R. Johnson, C. D. Ziebell, D. R. Patten, P. F. Ffolliot, and R. H. Hamre, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-120.

———. 1986. Changing landscapes and the cosmopolitism of the eastern Colorado avifauna. Wildl. Soc. Bull. 14:132–142.

——— AND R. W. CANNON. 1982. Structural resilience of a willow riparian community to changes in grazing practices. Pages 198–207 *in* Wildlife-livestock relationships symposium: Proc. 10. (J. M. Peek and P. D. Dalke, eds.) Univ. Idaho For., Wildl. and Range Exp. Stn., Moscow, Idaho.

——— AND T. E. OLSON. 1984. Naturalization of Russian-olive: implications for Rocky Mountain wildlife. Wildl. Soc. Bull. 12:289–298.

MANTELL, M., P. METZGER, AND C. REID. 1985. Improving riparian protection by linking state programs. Pp. 421–435 *in* Riparian ecosystems and their management: reconciling conflicting uses (R. R. Johnson, C. D. Ziebell, D. R. Patten, P. F. Ffolliot, and R. H. Hamre, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-120.

MCCALL, J. D. AND R. F. KNOX. 1979. Riparian habitat in channelization projects. Pp. 125–128 *in* Strategies for protection and management of floodplain wetlands and other riparian ecosystems (R. R. Johnson and J. F. McCormick, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-12.

NORSE, E. A., K. L. ROSENBAUM, D. S. WILCOVE, B. A. WILCOX, W. H. ROMME, D. W. JOHNSTON, AND M. L. STOUT. 1986. Conserving biological diversity in our national forests. The Wilderness Society. Washington, D.C.

OLSON, T. E. AND F. L. KNOPF. 1986a. Agency subsidization of a rapidly spreading exotic. Wildl. Soc. Bull. 14:492–493.

——— AND ———. 1986b. Naturalization of Russian-olive in the western United States. West. J. Appl. For. 1:65–69.

RISSER, P. G., J. R. KARR, AND R. T. T. FORMAN. 1984. Landscape ecology direction and approaches. Illinois Nat. Hist. Surv. Spec. Publ. No. 2. Champaign, Illinois.

ROBINSON, T. W. 1965. Introduction, spread and areal extent of saltcedar (*Tamarix*) in the western states. U.S.D.I. Geol. Surv. Prof. Pap. 491-A.

SAMSON, F. B. AND F. L. KNOPF. 1982. In search of a diversity ethic for wildlife management. Trans. North Am. Wildl. and Nat. Resour. Conf. 47:421–431.

SCHMIDLY, D. J. AND R. B. DITTON. 1979. Relating human activities and biological resources in riparian habitats of western Texas. Pp. 107–116 *in* Strategies for protection and management of floodplain wetlands and other riparian ecosystems (R. R. Johnson and J. F. McCormick, tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. WO-12.

SCHMITT, C. G. 1976. Summer birds of the San Juan Valley, New Mexico. New Mexico Ornithol. Soc. Publ. No. 4.

SEDGWICK, J. A. AND F. L. KNOPF. 1987. Breeding bird response to cattle grazing of a cottonwood bottomland. J. Wildl. Manage. 51:230–237.

SHARITZ, R. R. AND J. W. GIBBONS (EDS). 1988. Freshwater wetlands and wildlife symposium. Savannah River Ecol. Lab. Symp. Ser. (In press).

SIMPSON, G. G. 1965. The geography of evolution. Chilton Books. Philadelphia, Pennsylvania.

STAUFFER, D. F. AND L. B. BEST. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. J. Wildl. Manage. 44:1–15.

STEVENS, L. E., B. T. BROWN, J. M. SIMPSON, AND R. R. JOHNSON. 1977. The importance of riparian habitat to migrating birds. Pp. 156–164 *in* Importance, preservation and management of riparian habitat: a symposium (R. R. Johnson and D. A. Jones, Jr., tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-43.

SZARO, R. C. 1980. Factors influencing bird populations in southwestern riparian forests.

Pp. 403–418 *in* Workshop proceedings: management of western forests and grasslands for nongame birds (R. M. DeGraaf, tech. coord.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. INT-86.

THOMAS, J. W., C. MASER, AND J. E. RODIEK. 1979. Wildlife habitats in managed rangelands—the Great Basin of southeastern Oregon. Riparian Zones. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. PNW-80.

U.S. DEPARTMENT OF AGRICULTURE. 1980. Forest Service manual. Title 2500, watershed management. Washington, D.C.

———. 1982. An analysis of the timber situation in the United States 1952–2030. For. Resour. Rep. No. 23.

U.S. DEPARTMENT OF INTERIOR. 1984. Summary statistics. Vol. 1. Water, Land, and Related Data. Bur. Reclamation, Water and Land Tech. Serv., Code D-405. Denver, Colorado.

WARNER, R. E. AND K. M. HENDRIX, EDS. 1984. California riparian systems. Univ. Calif. Press. Berkeley, California.

WAUER, R. H. 1977. Significance of Rio Grande riparian systems upon the avifauna. Pp. 165–174 *in* Importance, preservation and management of riparian habitat: a symposium (R. R. Johnson and D. A. Jones, Jr., tech. coords.). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-43.

WHITTAKER, R. H. 1975. Communities and ecosystems. MacMillan Co., New York, New York.

WILLSON, M. F. AND S. W. CAROTHERS. 1979. Avifauna of habitat islands in the Grand Canyon. Southwest. Nat. 24:563–576.

WILSON, L. O. 1979. Public forum. Pages 77–87 *in* Grazing and riparian/stream ecosystems. (O. B. Cope, ed.). Trout Unlimited, Inc. Denver, Colorado.